The STOVL Joint Strike Fighter in Support of the 21st Century Marine Corps

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EXECUTIVE SUMMARY

Title: The STOVL Joint Strike Fighter in Support of the 21st Century Marine Corps

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Thesis: The potential basing flexibility and firepower that the Joint Strike Fighter (JSF) offers the Marine Corps in support of Operational Manuever From the Sea (OMFTS) will not be realized with the doctrine, mindset, and equipment that currently determines how we operate and support STOVL jets on amphibious ships and ashore in an expeditionary environment.

Background: In the 21st Century the JSF will replace both the F/A-18 and the AV-8B as the USMC fulfills its goal of an all-STOVL aviation component. STOVL aircraft increase basing flexibility which is fundamental to the expeditionary nature of the Marine Corps and provides the foundation for improved responsiveness. OMFTS seeks to avoid establishing a traditional logistics base ashore and the majority of firepower, to include aviation, will remain afloat and only go ashore if necessary. This means that the JSF will operate primarily from naval ships versus land bases. The JSF will be a far more capable aircraft than the AV-8B, but if the shipboard environment that it operates in is one which remains marginalized and biased against effective fixed-wing operations, we will not fully realize the JSF's firepower and flexibility.

Forward basing tactical aircraft reduces the distance to the battlefield and improves response times and aircraft surge rates. Operating jet aircraft from dispersed sites is a big logistical challenge. The Marine Corps does not have enough equipment to supply significant amounts of fuel and ammo to maneuver units. Relying almost exclusively on aviation to supply forward bases will place an enormous burden on already limited vertical lift capability.

Recommendations: The Navy-Marine Corps team must develop and refine STOVL employment concepts that includes ramps (ski jumps) and smaller EAFs and it must fund the hardware and structural improvements that allow STOVL aircraft to operate in their intended environment. If we envision maintaining a primarily sea-based approach to conducting operations and we require responsive day/night air support in all-weather conditions, then we need to fundamentally change how we operate fixed-wing jets off amphibious ships. The most significant contribution that the Navy could make to STOVL air and helicopter-borne power projection is adding a ramp to all LHA/LHD

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class amphibious ships. A dedicated " JSF carrier", such as an LHA/LHD with a ramp and updated radars, would serve as the optimum mobile forward base.

Although the most effective means of employing the JSF would be to base it ashore as soon as possible, it should remain sea based for as long as possible where it can be more easily provided with fuel, ordnance, and maintenance without becoming a logistical burden. Seabasing may remain the best means of enhancing sustainability and reducing vulnerability.

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I. Marine Corps All-STOVL Aviation Component

In the year 2008, the Joint Strike Fighter (JSF) will begin to replace both the F/A-18 and the AV-8B as the United States Marine Corps (USMC) starts to fulfill its goal of an all-Short Takeoff and Vertical Landing (STOVL) aviation component. This commitment, as stated in the 31st Commandant's Planning Guidance, will enable Marine aviation to continue "providing effective support to the Marine Air Ground Task Force across the spectrum of conflict" while "enhancing its expeditionary utility."[1] Having a single fighter/attack airframe will improve maintenance, reduce footprint, simplify planning, and improve operations.

The JSF will also be fielded by the US Air Force (USAF), US Navy (USN), and possibly the Royal Navy (RN). The single-seat, single-engine JSF will have to pack a lot of capability into a small package and at a relatively low cost. The USMC is the only US service that currently has a requirement for the JSF to be STOVL capable. This capability will cost between $3 to $7 million per jet more than the USAF version. How will our amphibious ships, carriers, and expeditionary fields support the JSF? Will the operational concept of employment for the JSF be the same as it has been historically for the AV-8B Harrier?

The STOVL JSF may be the aircraft that the Marine Corps has been searching for since 1958 to finally silence the STOVL critics and perform all the missions envisioned for STOVL fighter/attack aircraft. Or technological limitations and lack of support from both within the Marine Corps and other US services may render it another concept aircraft that never reached its potential. Will the JSF answer the Corps' requirements in

the 21st century or will the JSF fall short because of the Corps' failure to fully support and exploit expeditionary basing options? This paper will study the historical operational deployment of STOVL jets and the future concept of employment of the JSF in support of Marine expeditionary operations.

II. Joint Strike Fighter Program

Background. As the Armed Forces are reduced and restructured, the United States must preserve a core force structure organized, equipped, trained, and supported to meet a full range of military operations. Many of these operations require the US to project power using forces from the continental United States, forward land bases, and forward sea bases.[2] The Secretary of Defense's Bottom-up Review (BUR) in FY 1994 acknowledged the Services' need to replace their aging strike aircraft in order to maintain the US's combat technological edge. The Joint Strike Fighter (JSF) Program is the Department of Defense's focal point for defining next generation strike aircraft weapon systems for the Air Force, Navy, Marine Corps, and our allies.[3] The "focus of the program is affordability--reducing the development cost, production cost, and cost of ownership of the JSF family of aircraft."[4] Interservice commonality and compatibility with existing systems and infrastructure will be key to the affordability of this weapon system. The following cost per jet represents a preliminary program objective (Fiscal

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1 Charles C. Krulak, General, USMC, "The 31st Commandant's Planning Guidance," August 1995, A-8-A9.

2 Director, Joint Strike Fighter Program memorandum for Distribution, subject: "Joint Initial Requirements Document (JIRD) for Joint Strike Fighter dtd 15 August 1995," 29 April, 1996, 2.

3 Joint Strike Fighter Program Home Page, "JSF Program White Paper," downloaded from *World Wide Web*, http://www.jast.mil/new/whtpapr.html., 29 October 1996, 1.

4 Joint Strike Fighter Program Home Page, "JSF Program White Paper," 1.

Year 1994 dollars, production rate of 170 aircraft per year): USAF:$28million; USN: $31-$38million; USMC: $30-$35million.[5]

The JSF program has been built upon a foundation that includes simulation-assisted wargaming analyses of the Defense Planning Guidance (DPG)-based Major Regional Contingency scenarios in the 2010 timeframe.[6] The regional threat projected by DIA and service intelligence branches will become more sophisticated, mobile, and integrated. The USAF, USN, and USMC must be capable of striking and destroying a broad range of targets, day or night, and in adverse weather conditions.

Requirements. The first formal product of the requirements definition process was the Joint Initial Requirements Document I (JIRD I) which was signed by the three services and endorsed by the Joint Requirements Oversight Council (JROC) in the summer of 1995. The JROC endorsed the JSF process and "family of aircraft" strategy and emphasized "the great potential towards achieving an affordable solution to meet our joint warfighting capability."[7] The "family of aircraft" concept allows for a high level of commonality while satisfying unique service needs and also has the cost benefits of a common maintenance depot, a commonly supported logistics tail, and increased service interoperability.[8] The Concept Demonstration Phase (CDP) commenced in November 1996 with the selection of Boeing Company and Lockheed Martin Corporation as the two prime contractors who will compete to build the production JSF. During the four-year CDP, each company will build and flight test two airplanes, a STOVL variant to

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5 Director, JSF Program, "Joint Initial Requirements Document (JIRD)", 8.

6 Joint Strike Fighter Program Home Page, "Requirements Definition," downloaded from *World Wide Web*, http://www.jast.mil/Master Plan/1996/Section5.htm., 27 September 1996, 1.

7 Joint Strike Fighter Program Home Page, "JSF Program White Paper," 1.

8 Joint Strike Fighter Program Home Page, "JSF Program White Paper," 2.

demonstrate hover and transition to horizontal flight, and a carrier-based variant to demonstrate aero-handling qualities and up-and-away performance.[9] The CDP acquisition strategy has the advantages of maintaining a competitive environment prior to Engineering and Manufacturing Development (EMD), providing for two different STOVL approaches and two different aerodynamic configurations, and demonstrating the viability of a multi-service family of variants.[10] EMD of the JSF program commences in FY 2001. Initial Operational Capability (IOC) of the resulting aircraft variants is expected in about 2010.[11]

The largest customer, the USAF, needs an affordable replacement for the F-16 and A-10: a total of about 2,000 aircraft, primarily attack aircraft with an acceptable air-to-air capability. The USN requires 300 stealthy, long-range, survivable strike aircraft to complement the F/A-18E/F, and the USMC requires about 600 short take-off/vertical landing (STOVL) aircraft to replace AV-8B's for close air support and F/A-18's for day/night attack and air superiority. The UK's Royal Navy needs 90 multirole STOVL aircraft to replace the Sea Harrier with an in service date of 2012.[12] This program has the potential to produce 3,000 aircraft and could be a candidate to replace most of the fighters which the US exported in the 1970's and 1980's.

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9 Boeing News Release, "Boeing Wins Joint Strike Fighter Contract," downloaded from *World Wide Web,* http://www.boeing.com/news.release.961116.html, 16 November 1996, 1. DefenseLINK News, "DOD Selects Boeing and Lockheed Martin to Develop JSF," downloaded from *World Wide Web,* http://www.dtic.dla.mil/defenselink/news, 16 November, 1996, 1.

10 Joint Strike Fighter Program Home Page, "JSF Program White Paper," 2.

11 Joint Strike Fighter Program Home Page, "Introduction," 3.

12 Bill Sweetman, "Decision Day Looms for Joint Strike Fighter" Janes International Defense Review, (9/1996): 36.

The JSF Program analysis has identified four critical characteristics necessary for improved multi-mission capabilities: lethality, survivability, supportability/deployability, and affordability.[13] These key characteristics will drive the JSF design and capabilities.

Interservice commonality improves sortie generation rates and enhances deployability through the use of common parts, supply, maintenance, and user familiarity. A common strike aircraft with the flexibility to quickly change roles during combat operations is essential to meet the theater commander's combat power requirements. The JSF should support all the services needs while achieving a cost effective balance of signature, speed, maneuverability, payload, range, and supportability.[14]

One difference between the JSF and earlier attempts to meet a wide spectrum of requirements in a single design (such as the F-111 and Tornado) is that the JSF customers teamed up early and separated the core requirements from "nice-to-have" peripheral and expensive attributes.[15]

USMC JSF. The USMC requirement for expeditionary and forward-based tactical aircraft mandates a multi-mission aircraft capable of operations from austere shore facilities as well as amphibious ships and other sea bases. Basing flexibility is fundamental to the expeditionary nature of the Marine Corps and provides the foundation for forward basing which improves responsiveness. Basing flexibility is the only reason to buy STOVL Joint Strike Fighters. This flexibility increases the number of airfields from which to conduct operations, allows for more assets to be brought into theater,

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13 Joint Strike Fighter Program Home Page, "Requirements Definition," 2.

14 Director, JSF Program, "Joint Initial Requirements Document (JIRD)", 3.

15 Sweetman. 36.

decreases the response time of aircraft, and provides dispersal for high-value assets, thus reducing vulnerability to attack by weapons of mass destruction.[16]

Some critics have attacked the STOVL JSF variant for driving up cost and slowing the schedule, and they contend that the Marine Corps and Navy should both buy the Air Force version. Senior Pentagon acquisition officials believe that the Air Force and Navy should buy the STOVL version, "a capability that would let the Air Force operate from shorter, rougher fields, thus moving closer to the battlefield and providing wider deployment and basing options."[17] A Development Study on the JSF conducted by ten students from the Navy, Marine Corps, and Air Force at the Air War College in 1996 emphatically states that the JSF must be expeditionary and capable of performing in the littoral arena and that the STOVL JSF should be the choice of the US. The JSF should be one aircraft, not three derivatives.[18]

As the JSF, or STOVL Strike Fighter (SSF) as the Marine Corps calls it, becomes the "neckdown" replacement for the AV-8B and F/A-18, it will fulfill missions in four of the six functions of Marine Aviation: Anti-Air Warfare, Offensive Air Support, Aerial Reconnaissance, and Control of Aircraft and Missiles (TACA/FACA). The Corps will keep the F/A-18D as long as possible to fill any TACA/FACA void, although there is the possibility that with the technological advances of 21st century command and control, we may not need a traditional TACA/FACA platform.[19] If the JSF concept

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16 Director, JSF Program, "Joint Initial Requirements Document (JIRD)", 6.

17 David Fulghum, "Joint Strike Fighter Update." *Proceedings,* September 1996, 40.

18 Derek W. Avance, Christopher S. Ceplecha, Robert E. Clay, Terry M. Featherston, David S. Grantham, Patrick A. Kelleher, David Kelly, Garry L. Pendleton, John Rupp, Christopher E. Yelder, *The Joint Strike Fighter,* Development Study (Maxwell Air Force Base, Alabama: Air Command and Staff College, April 1996), 9, 14.

19 Pete E.Yount, LtCol, USMC, USMC JSF Program at Headquarters USMC, interview by author, 11 December 1996.

demonstrators fail to fly a solid, viable, STOVL variant, the Marine Corps may lose the AV-8B replacement. This will be a critical decision point for the Corps. This may mean abandoning the pursuit of an All-STOVL aviation component for at least the first part of the 21st Century and buying the new Navy F/A-18 E/F.

The Marines want 642 JSFs to fill all twenty-three active duty F/A-18 and AV-8B squadrons, four reserve F/A-18 squadrons, and training squadrons. This number is based on eighteen year attrition at 2% per year.[20]

The emphasis of the JSF program, and particularly for the Marines, is air to ground. The Air Command and Staff College development study proposes that the JSF utilization will predominantly fall within the realm of close air support and interdiction. Expensive stealth aircraft and cruise missiles will continue to perform the deep strike mission. Therefore the JSF program should concentrate its efforts on producing an aircraft unmatched in the performance of close air support and interdiction.[21] According to USMC Colonel Duane Thiessen, the Marine Operational Requirements Officer for the JSF Program, the Marine Corps main concern is that the JSF needs to provide CAS day or night against any threat.[22] Colonel Thiessen envisions the JSF using internal weapons from 30,000 feet and 15 miles stand-off. Accurate precision weapons and the use of off-board systems such as satellite exchange and data link will provide this capability.

The JSF will carry internal weapons against heavily defended targets in a stealth mode, and will have at least four external hardpoints to carry larger loads. In low threat environments it could carry external stores from day one. JSF could attack more targets

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20 Yount interview.

21 Avance and others, 13.

in its non-stealthy, high-payload configuration as a campaign progresses and enemy defenses are degraded. Large stand-off weapons will be carried externally. The USMC minimum requirements are: airframe stressed to withstand +8 to -3 G's (force of gravity), 750 knots/1.5 Mach top-end speed, very low observable carriage of weapons (two 1,000 pound-class precision bombs and 2 advanced air-to-air missiles), 4 external stations (at least two with capability of carrying external fuel tanks), a 450 nautical mile mission radius (internal payload), maximum of 450 foot takeoff distance for a short takeoff (sea level, tropical day, no wind), and night all weather precision strike capability.[23] The Marine variant will be less stealthy than the others and will pay penalties in both RF and IR signature due to such modifications as additional doors required for STOVL operations.[24]

It has been acknowledged that the "number one challenge (in the JSF program) is the integrated flight/propulsion system on the Marine airplane."[25] The engine for the JSF will have to be extremely reliable. Reliable because the JSF, like the Harrier, will be a single-engine aircraft, and when operating in the vertical or slow flight mode at speeds which do not produce any aerodynamic wing lift, the jet and the pilot will be *living* on that single engine. This engine must produce enough thrust to allow the jet to operate in the STOVL mode on hot, summer days in the Mediterranean Sea, the Persian Gulf, or Yuma, Arizona. If carrying expensive Precision Guided Munitions (PGM's), either internally or externally, and operating off amphibious ships, the JSF needs to have the

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22 Duane Thiessen, Col, USMC, Marine Operational Requirements, JSF Program, telephone interview by author, 27 September 1996.

23 Yount interview.

24 Yount interview.

performance to allow vertical landings while retaining these PGM's if they were not expended in the mission.

Both Boeing and Lockheed Martin have selected derivatives of the Pratt & Whitney (P&W) F119 engine to power their JSF demonstrator aircraft. The engines will use a stock F119 engine core, with the nozzle, fan and controls tailored to individual aircraft requirements. The F119-PW-100 engine is a 35,000 pound-thrust class engine being developed by Pratt & Whitney to power the USAF F-22 air superiority fighter. The F119, which has far fewer and more durable components than existing fighter engines, can operate at supersonic speeds for extended periods without using an afterburner.[26] The F119 was designed for single-engine safety, with duplicate control systems and fuel pumps. The Air Force has spent more than a billion dollars developing the F119 engine and the JSF will "benefit enormously from the maturity and the performance of the F119."[27] General Electric (GE) received a contract to begin work on the F120 engine from the F-22 competition that would compete with the P&W F119. Admiral Craig Steidle, JSF Program Director, said the JSF will eventually fly with both the P&W and GE engines and hopes that the JSF program reaps the long-term cost and warranty benefits of having two competing engine suppliers.[28]

Single-engine aircraft are a risk, but the economic advantages (cost of one engine versus two per jet) over a two-engine platform are impressive. The preliminary results of two independent studies indicate the technologies are available to produce a single-

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[25] William B. Scott, "Lockheed Martin Chooses Conventional JAST Design," *Aviation Week and Space Technology*, 11 December 1995, 52.

[26] Glenn W. Goodman, Jr., "Wanted: Vertical Lift," *Armed Forces Journal International*, September 1995, 40.

[27] Goodman, "Wanted: Vertical Lift," 40-41.

engine airplane that would have the same reliability currently available in a two-engine airplane.[29] But not only does the engine have to be incredibly reliable mechanically, single engine aircraft are a lot easier to shoot down. All three NATO jets shot down over Bosnia were single engine jets (Harrier, F-16, and Mirage 2000). Five single-engine AV-8Bs were shot down in Desert Storm whereas all five USMC twin-engine F/A-18s hit by Iraqi SAMs flew back home with battle damage. That second engine is insurance against both mechanical failure and battle-damage. To improve single-engine survivability contractors are looking at graduated levels of signature reduction (radar cross-section and infrared heat source that affect the enemy's ability to acquire and target aircraft) for each version of the baseline aircraft. For the Marine Corps, with close air support in mind, infrared signature control is more critical than radar signature.[30]

III. Why STOVL JSF?

The main advantage of Vertical/Short Takeoff and Landing (VSTOL) aircraft is the ability to operate from various bases and not be tied to traditional runways and airfields.[31] Modern runways, long and wide, are inviting targets. Runways will always be susceptible or vulnerable to attack, and the need for aircraft to take off with little or no runway will always be desirable. The major attraction of VSTOL type aircraft is their

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[28] Glenn W. Goodman, Jr., "Joint Strike Fighter," *Armed Forces Journal International,* February 1996, 15.

[29] John D. Morrocco, "JAST To Be Single Seat/Engine Design," *Aviation Week & Space Technology,* 6 February 1995, 22.

[30] Morrocco, "JAST To Be Single Seat/Engine Design," 23.

[31] Most modern conventional jet aircraft need at least 8,000 feet of hard-surfaced runway to operate off of with longer runways in excess of 10,000 feet more desirable. Both VSTOL and STOVL are somewhat interchangeable and refer to aircraft that can takeoff and land vertically or in very short distances. The difference is in the proposed method of operation. STOVL is more accurate as it implies a Short Take Off and a Vertical Landing, which is the preferred way to operate the Harrier (and the only way Harriers operate off of ships). A STOVL jet can takeoff with a much higher payload of weapons and fuel using a rolling short takeoff of several hundred feet versus a pure vertical takeoff. Once the jet has

liberation from runways. Pre-emptive enemy action in the form of air attack or cruise missile attack forces the debate of the vulnerability of aircraft on the ground at fixed airfields. Aircraft or their runways and other facilities may be wrecked.

Historical Justification. History is replete with examples of extensive damage inflicted by attacking enemy airfields. During the Ardennes offensive, on New Year's Day, 1945, 1,000 Luftwaffe warplanes attacked 27 air bases in Belgium and Holland and destroyed 300 Allied aircraft on the ground for the loss of 93 of their own.[32] In 1967, the synchronized strike by Israel against 16 Arab fields determined the course of the Six Day War. On that first day, the Israelis destroyed over 250 Arab aircraft on the ground in only three hours.[33] One of the most persuasive arguments for the STOVL concept comes from the Indo-Pakistan war of 1971. Forty-eight hours after the start of hostilities a Pakistani airfield at Dacca had been attacked repeatedly. A squadron of Pakistani Super Sabre jets remained intact under the protection of their hardened shelters, yet they never flew a single sortie because the runway had been cratered.[34] STOVL aircraft could have taken off vertically or on short sections of usable runway and could have been employed.

USN/USAF and VSTOL. The US Navy abandoned its quest for VSTOL combat aircraft in 1956. Reasons for this were not motivated soley by technical problems but rather because there was a powerful, senior element in the US Navy dedicated to the

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expended all or most of the ordnance and fuel, it has the ability to land vertically due to the decreased weight.

[32] Neville Brown, *The Future of Air Power* (New York: Holmes & Meier Publishers Inc., 1986), 178.

[33] Brown, 179.

[34] Bruce Myles, *Jump Jet The Revolutionary V/STOL Fighter* (London: Brassey's Defence Publishers, 1986), 181.

proliferation of the aircraft carrier as the major fleet combatant. So long as funding could be provided for large carriers, the pattern of naval combat aircraft was predictable.[35]

It is difficult to fault the USN for not embracing VSTOL aircraft or small carriers. The best VSTOL jet in the world, the Harrier, cannot match the performance or payload of front-line Navy aircraft such as the F/A-18, F-14, or A-6E. As long as the US is willing to fund ($4.7 billion for the latest carrier, the USS *John C. Stennis)* and build super carriers that can carry up to 80 tactical aircraft and can fulfill virtually every mission in the airwarfare spectrum, there is no incentive to commit to smaller VSTOL carriers like those of the UK Royal Navy. A USN nuclear-powered aircraft carrier is a formidable weapon but also a lucrative and attractive target. The Navy argues that the carrier has a host of aircraft that exploits the complete capability of air power, but the majority of the aircraft carried aboard today's carrier are dedicated to CVBG (carrier battle group) defense and the ability to deliver firepower ashore is greatly reduced. "Lacking a better tactical air power projection scheme, however, the Navy's doctrine and funding have continued without serious opposition."[36]

With the US Navy's commitment to large-deck carriers and conventional aircraft, how do we intend to integrate the STOVL JSF with conventional JSF's when the Navy perceives STOVL aircraft to be a threat to their way of doing business? The Navy intends to buy 1,000 F/A-18E/Fs and only 300 *conventional* JSFs. The Navy simply does not believe in operating fixed-wing STOVL aircraft from CVs. The *potential* for STOVL aircraft in naval aviation is, however, extraordinary.

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35 Francis K. Mason, *Harrier* (Annapolis: Naval Institute Press, 1983), 8.

36 Jeffrey C. Prater, Maj, USAF, "VSTOL and Power Projection," *Airpower Journal* , Summer 1991, footnote 6, page 68.

From June 1976 to April 1977, VMA-231 deployed with 14 AV-8As aboard the USS *Franklin D. Roosevelt* (CV-42). This deployment demonstrated that the Harrier could be completely integrated into normal CV air operations. Almost every conceivable takeoff and recovery option was flown: upwind, downwind, crosswind, and before, during, and after re-spots. The Harrier demonstrated not only that VSTOL operations could be conducted within the rigid framework of cyclic operations, but that because of VSTOL's inherent flexibility, a carrier can launch and recover at any time and steam wherever desired while achieving a combat capability that does not exist when using only conventional aircraft.[37] A STOVL jet is unrestrained by launch/recovery times and mission permitting, could fill in gaps created by the CV cycle.[38]

STOVL pilots never have to worry about catapult problems or missing an arresting wire. There is no such thing as a "bolter" (aircraft misses the arresting wires) in the Harrier. If the pilot can find the ship, he is going to land. The boarding rate is virtually 100%. The Harrier is also the only landbased fixed-wing aircraft to have been operated routinely from ships without a single modification to the airframe, and it dispenses with much of the complicated equipment required by conventional naval aircraft.[39]

If the STOVL JSF is successful, the Navy may be pressured to buy them. In 1992 a senior American naval official said if the Navy is not allowed to keep big deck carriers in the numbers that they are used to then they will have to make some hard

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[37] U.S. Marine Corps, *U.S. Marine Corps AV-8 V/STOL Program, Fourth Edition* (GP32-0504, 1 April 1994), A-13.

[38] William R. Jones, Major, USMC, *AV-8B In Defense Of The Amphibious Task Force*, Thesis. (Newport, R.I.: Naval War College, March 1985), 14.

[39] Sweetman, 39.

choices and that, "If ASTOVL (Advanced STOVL) is viable, then you will be able to put your aviation at sea on a different type of carrier."[40]

USAF Major Jeffrey Prater believes that advances in VSTOL and other technologies offer potential mobility formerly undreamed of for wing-sized units. These advances permit the US Air Force to abandon the "archaic concept of hardening air bases deep in the theater rear area for survivability, while at the same time putting the machines closer to the battle."[41] The White House Commission on Integrated Long-Term Strategy reported in 1988 that the United States must develop alternatives to overseas bases because it is getting increasingly difficult and politically costly to maintain bases overseas.[42] Recent years have witnessed a significant reduction in US overseas bases. Reductions have been the result of both voluntary closures and sovereign nation actions. Basing rights in future operations could be limited. This was driven home recently with the 1996 strikes against Iraq. The US had to resort to cruise missile attacks and lost the option of using land-based aircraft in theater when Turkey, Jordan, and Saudi Arabia would not allow US air strikes to be launched from their territory (USN carriers were on-station in the Persian Gulf but were not used for the attacks). USAF General Charles A. Horner, commander of all Allied air forces in Operation Desert Storm, also believes that US forces are far too dependent on foreign basing and that our "entire landbased fighter

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[40] Morrocco, "British Aerospace Teams on ASTOVL and Tiger," *Aviation Week & Space Technology,* 29.

[41] Prater, 63.

[42] Prater, 63.

force during the [1996] Iraqi crisis was effectively neutralized, leaving US military capabilities seriously circumscribed."[43]

Prater warns that the incentives to support VSTOL do not warrant an immediate jump to VSTOL. He states that a "phased approach based upon viable, long-range planning and acquisition strategies is the best course of action. We must first conceptually embrace the new basing scheme and fully adopt the technology."[44] As USAF Major General Thomas R. Ferguson put it, "We can't just push our technology into the operational world. There's got to be a pull from the other end."[45]

It is apparent that there are still very few, dedicated believers in the advantages of VSTOL when one takes a look at the most recently fielded operational fighters in the world and those under development. The Russian Su-27, Mig-29, Su-35, French Rafale, Eurofighter-2000, Swedish Gripen, and the USAF F-22, for example, are all modern non-VSTOL aircraft.

USMC and VSTOL. The Marine Corps has been interested in VSTOL since the mid-40's when helicopters first demonstrated the basing flexibility that did not require large landing fields or prepared sites. In the Pacific campaigns during WWII, Marine air and Marine ground troops did not operate as a team in the modern sense due to both a lack of technology and airfields on the islands where amphibious assaults were conducted.[46] This lack of responsive, organic air support was an unacceptable situation to the Corps. The Corps is heavily dependent on its air power to provide fire support that

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[43] Charles A. Horner, Gen USAF (Ret), "What We Should Have Learned in Desert Storm, But Didn't," *Air Force Magazine,* December 1996, 56.

[44] Prater, 66.

[45] Prater, 66.

the ground component lacks, especially heavy artillery and tanks. A USMC requirement had been written as far back as 1958 for a fixed-wing high performance VSTOL aircraft.[47]

The first operational VSTOL jet, the Harrier, flew on 31 August 1966. The Marines bought the Harrier off the shelf from Britain. After watching a promotional film on the Harrier in 1968, Major General Keith McCutcheon, USMC Deputy Chief of Staff for Aviation, decided that the Harrier was what they had been looking for and so they went and dusted off the 1958 VSTOL operational requirement file and went to work on getting the Harrier into the Corps' ranks. With a "mixture of political skill, hard work and sheer enthusiasm", they persuaded Congress to buy this revolutionary foreign airplane.[48] The Marine aviators were comparing it favorably to the combat-proven A-4 Skyhawk. The A-4 typically carried about 3000 pounds of ordnance in combat and based upon the current thrust of the Harrier's Pegasus engine and the weight of the airplane, the Marines figured that they had about 6,000 pounds to trade off between fuel and ordnance. With 3,000 pounds of bombs, they figured that the Harrier would have a radius of action of thirty-five to fifty miles and up to five minutes over the target. They also believed that the fifty mile radius was "probably a far greater distance than the aircraft would ever be asked to fly because its flexibility would allow it to be close to the battle."[49]

VSTOL Myths. The only reason that VSTOL aircraft exist is to provide basing flexibility. Despite all the propaganda put out by McDonnell Douglas, British

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[46] Myles, 150. Except for a handful of squadrons on small escort carriers in the last months of the war, Marine Aviation in WWII functioned as the *land* component of *naval* aviation.

[47] Myles, 151.

[48] Myles, 149.

[49] Myles, 157.

Aerospace, and other enthusiastic Harrier supporters, USMC AV-8Bs do not operate out of 72 foot-square pads in jungle clearings, tennis courts, clearings in the forest, village parking lots, or "basketball-court sized clearings near the front" other than at Bogue Field, North Carolina.[50] Can the Harrier fly out of those "exotic" locations? Yes, but unless occasionally demonstrating a capability or staging a demonstration, we simply do not do it and we do not support it. For example, the only two-lane road that the vast majority of USMC Harrier pilots have ever flown off of or landed on is Lyman Road in Camp Lejeune, N.C. In my own personal experience involving 1,300 hours of Harrier flight time which includes two deployments to the Mediterranean, a Western Pacific deployment, and Desert Shield/Desert Storm, I have never landed on a road or austere VSTOL pad except at Camp Lejeune. I have operated the AV-8B from short, deteriorated runways that would be unusable for conventional jets. The main-base expeditionary runway used by land-based Harriers in Desert Storm was 7900 feet in length, hardly a village parking lot. The Harrier forward site at Tanajib, Saudi Arabia, had an 8,000 foot runway (6,000 feet of asphalt plus 1,000 feet of concrete at both ends).[51] Except to prove the concept, USMC AV-8Bs do not operate off of grass strips either. If STOVL jets will take-off with full internal fuel and any significant payload, then a lot more than just a pad is needed.

Additional STOVL Concerns. Some of the problems inherent in STOVL operations include hot gas re-ingestion and foreign object damage (FOD) resulting from jet blast. By design, the hot gas exhaust nozzles of the Harrier are located further aft

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[50] Taken from McDonnell Douglas, British Aerospace, and Rolls Royce advertisements in various *Marine Corps Gazette* magazines.

from the engine air intakes than the cold (unheated air) nozzles. However, when hovering in light winds (or prolonged flying in ground effect) there is some mixing of the two gases due to expansion and interaction of the ground sheets so that some re-ingestion of hot gases can occur with consequent loss of engine efficiency and loss of thrust.[52] This is normally avoided by hovering into the wind so that the hot gases are blown aft and away from the engine intakes. Also, rolling or short take-offs, with the nozzles directing the exhaust aft, eliminates hot gas re-ingestion.

FOD is the one of the most difficult problems to overcome in any STOVL operation. Jet engines are scarce and expensive, and properly prepared surfaces minimize foreign object damage and permit safer flight operations, especially for single engine aircraft. When operating from unprepared surfaces, such as grass clearings or asphalt roads, the effect of vertical jet blast is swift and destructive. Since the exhaust is deflected downward in a hover or slow flight, a STOVL jet can dig a hole and tear up huge chunks of asphalt and flying debris that can either damage the airframe or be ingested into the engine. Again, the use of rolling takeoffs and rolling landings reduces the risk of FOD, and the relatively clean decks of ships make them ideal STOVL platforms. The increase in thrust for the JSF (35,000 pound-thrust class engine versus 23,000 pound-thrust class for the Harrier) will increase the energy directed on the landing surface and may increase the possibilities for self-induced FOD.

IV. STOVL OPERATIONS and the JSF in the 21st Century

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[51] Airfield data provided to the author in a pilot "Divert Info" packet utilized by Harrier pilots in Desert Storm.

[52] Mason, 177.

Operational Maneuver From The Sea . The centerpiece of the Marine Corp's future is an approach to expeditionary, littoral, and amphibious warfare known as Operational Maneuver From the Sea (OMFTS). OMFTS has been described as a state of mind. It represents a different, if not new, way of looking at warfare. The focus of future military operations will be in the coastal or littoral areas of the world. The Navy and Marine Corps have refocused their efforts to more effectively employ the Navy-Marine team in the littorals of the world. USMC combat aircraft must be capable of operating from aircraft carriers, amphibious ships and austere bases ashore, and performing a variety of missions as an integral part of a naval expeditionary force. One of the most compelling limitations facing US operational forces in the 21st century is the reduction of overseas bases and lack of host nation support. It is naive to assume that US forces will always have basing facilities within un-refueled range of tactical aircraft for future conflicts. The answer to this problem lies in the merits of expeditionary warfare.[53]

OMFTS seeks to avoid establishing a traditional logistics base ashore from which to conduct follow-on operations. Maneuver forces will move directly from the ship to their objectives with a minimal footprint. The majority of firepower, to include aviation, will remain afloat and only go ashore if necessary. The logistic footprint associated with current systems is excessive and results in lengthened deployment response time and stresses strategic lift capabilities. Reduced logistics footprint will enable improvements in reaction time to crisis response and rapid deployment of forces. The infrastructure of 20th century combat power--large dumps of fuel and ammunition, ships waiting for days to unload their cargoes, and crowded assembly areas--will make lucrative targets for the

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[53] Avance and others, 20-21.

weapons of the 21st century.[54] New weapons which will inevitably be wielded by at least some of our enemies, require that our units be hard to detect, far-ranging, and fast moving.[55]

The USMC Operational Concept for the JSF envisions it as an integral part of the Marine Air-Ground Task Force (MAGTF).[56] The JSF will provide lethal and flexible firepower for the MAGTF in support of OMFTS. Employment of the Marine JSF will be tailored to the size of the MAGTF that it is supporting, and the nature of the missions that the MAGTF is tasked to fulfill. As the JSF replaces the AV-8B Harrier it may be the only fixed wing aircraft present to directly support the Marine landing force. As ground forces are phased ashore, air operations from forward expeditionary facilities may be established. With an inherent ability to takeoff in short distances and land vertically, the basing options of the STOVL JSF are innumerable and the flexibility offered to the combatant commanders is unmatched.[57] The basing flexibility concept relies on roads, highways, expeditionary airfields, big-deck amphibious assault ships, carriers, and conventional runways.[58]

The current Marine Corps operational concept of VSTOL is to provide responsive offensive aviation support for ground forces during all phases of combat operations. This concept encompasses sea-based employment, early land-based employment, and

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54 *Operational Maneuver From The Sea*. Marine Corps Association, June 1996.

55 *Operational Maneuver From The Sea*.

56 US Marines organize for operations and are employed as integrated MAGTFs. There are three types of task forces: the Marine Expeditionary Force (MEF), the Marine Expeditionary Unit (MEU), and the Special Purpose Marine Air-Ground Task Force (SPMAGTF). All MAGTFs have four elements: a balanced force of aviation combat, ground combat, and combat service support elements organized around a command element.

57 Avance and others, 25.

ultimately, the phasing ashore of all aircraft operations and maintenance. It emphasizes forward basing coupled with a flexible basing posture to exploit the unique characteristics of VSTOL aircraft.[59] The emphasis on the early land basing and the goal of ultimately phasing ashore all aircraft operations and maintenance is in direct contrast to the tenets of the Marine Corps' vision for conducting warfare in the 21st century under the concept of OMFTS.

Shipboard Operations. In the absence of an adjacent land base, a sustainable forcible entry capability that is independent of forward staging bases, friendly borders, overflight rights, and other politically dependent support can come only from the sea.[60] The OMFTS concept envisions a minimal footprint ashore with most if not all fire support and logistics remaining sea-based. This means that the JSF will operate primarily from naval ships and usually exclusively from ships versus land bases. If the Marine Corps intends to operate the JSF on USN amphibious ships as we currently operate the Harrier, then the problems that continue to plague the employment of the Harrier onboard these ships will be inherited by the JSF unless changes are made.

Major Jon T. Hoffman, in "The Future Is Now", writes that the most threatening military challenges on the horizon are weapons of mass destruction, precision-guided munitions, and unconventional warfare. Major Hoffman believes that the Marine Corps can address these threats and the problems associated with them by moving towards sea-basing and a style of warfare built around indirect firepower, such as aviation. "Sea-

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[58] Charles R. Myers, Major, USMC, *STOVL Air Power, The Ramps, Roads, and Speedbumps to Exploiting Maneuver Air Warfare,* Military Issues Paper, (Quantico, Va: Command and Staff College, April 1996), 4-5.

[59] U.S. Marine Corps, *U.S. Marine Corps AV-8 V/STOL Program, Fourth Edition* (GP32-0504, 1 April 1994, 2-1.

basing keeps the maximum slice of a military force at sea, where it is much less vulnerable. Placing increased emphasis on indirect firepower makes sea-basing practical, reduces the cost of the force, and makes our ground forces much more effective."[61] Sea-based aviation will be the MAGTFs most lethal and flexible means of indirect firepower. Keeping aviation at sea reduces the logistical and maintenance burden while providing enhanced security. Sea-basing would thwart an enemy hoping to counter our conventional superiority with weapons of mass destruction. He would find no significant military targets ashore to shoot at and would have a hard time striking mobile targets at sea.[62]

As we look forward into the 21st century, we need to address how the JSF will be integrated into the Aviation Combat Element (ACE) of a MEU.[63] Of all the various MAGTFs, the MEU is by far the most commonly deployed and utilized by the National Command Authorities. A representative ACE composition would likely include twelve MV-22 tiltrotor aircraft, four CH-53E heavy lift helicopters, six AH-1W attack helicopters, two UH-1N utility helicopters, and six STOVL JSF aircraft. For deployment aboard LHD-class ships, this aircraft composition should not pose any insurmountable challenges, regarding space either on the flight deck or the hanger deck. With the stated requirement that the JSF not require any greater deck space than an F/A-18, the JSF may create additional space challenges when replacing AV-8B aircraft on amphibious assault

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60 *Operational Maneuver From The Sea*.

61 Hoffman, Jon T., Major, USMCR. "The Future Is Now." *Proceedings,* November 1995, 29-33.

62 Hoffman, 32.

63 Mark S. Barnhart, *The Joint Strike Fighter,* Air War College Research Report (Maxwell Air Force Base, Alabama: Air War College, April 1996), 13.

ships (an F/A-18 is larger than an AV-8B).[64] The number of JSFs deployed will be dependent upon the MAGTF mission, amphibious lift, and other factors. For every JSF embarked on an amphibious ship, one or more helicopters will be unavailable.[65] "This spot limitation alone is of prime consideration to the MAGTF commander since no part of amphibious operations is without tradeoffs and compromise."[66]

With the JSF currently existing only as an engineer's concept, we are forced to examine both the potential and limitations of employing fixed-wing STOVL jets from Navy ships by examining the employment of the AV-8 Harrier over the past twenty-plus years. The preponderance of operational STOVL jet employment experience has been with the MEU. Unlike Navy and Marine squadrons that deploy aboard carriers (including USMC F/A-18 squadrons), AV-8B's currently normally deploy at sea as six-plane detachments with MEUs on amphibious assault ships (LHDs and LHAs).[67] Some of the very few exceptions to these six plane detachments have been a three month VMA-231 deployment with 20 AV-8As (no helos) on the USS *Nassau* in 1981 and the eight month VMA-331 squadron deployment onboard the USS *Nassau* in 1990-1991 with 20 AV-8Bs. Our current doctrine does not optimize the firepower of fixed-wing jets when flown from amphibious ships. "As Marines transition to an all-STOVL TACAIR component, their reliance on the Navy grows more critical to provide the most capable sea-based platforms possible within budget constraints. Current amphibious assault ships

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64 Barnhart, 13-14. The F/A-18 is 56 feet in length with a wingspan of 40 feet, while the AV-8B is 46 feet in length with a 30 foot wingspan.

65 Jones, 11.

66 Jones, 12.

67 LHD and LHA class amphibious assault ships, or L-Class ships, resemble small aircraft carriers and are designed to carry combat troops and weapon systems, including helos and AV-8Bs.

deny STOVL aircraft full combat payloads."[68] USN carriers are designed and operated to do one thing: project fixed-wing combat power at sea or ashore. Amphibious ships sometimes have multiple missions such as command and control, medical, well-deck operations, Harrier operations, and helo operations.

Simultaneous Harrier and helo operations results in less than optimum utilization of both. It is inherently difficult to do combined fixed and rotary wing operations. Helo and fixed-wing recoveries can be done simultaneously during the day with good weather and with caution during marginal weather. Night operations need to be conducted separately.[69] There is limited space onboard the ship, and competition over assignment of ship spaces and deck time. The Marine Corps Lessons Learned System highlights numerous problems in trying to do too much with one ship such as an LHD or LHA. A Marine operations officer involved with Exercise Dragon Hammer 1990 stated, "There were significant problems coordinating launch cycles with helicopters and AV-8s. It restricted rapid build-up of combat power ashore and dramatically reduced the responsiveness of aviation assets."[70] Although simultaneous or near simultaneous flight operations can be obtained with AV-8Bs and helos, the resultant penalty to both is too costly.[71] We are trying to do too much with one platform and compromises are usually made that reduce the effectiveness of some of the MAGTF's assets. Colonel Kevin

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[68] Meyers, 5.

[69] Kevin S. Vest, Major, USMC, Marine AV-8B and CH-53 pilot with extensive experience flying off L-class ships. Formally the senior training Landing Signal Officer (LSO) for MAG-13, interview by author, 4 April 1997.

[70] Operations Officer, Marine Corps Lessons Learned, "Exercise Dragon Hammer 90," 14 May 1990.

[71] H.J. Coble, Maj, USMC, "Marine Corps Lessons Learned System," #31246-77641, 12 March 1991. Major Vest disagrees and stated that "with planning on behalf of the ship and the ACE, simultaneous ops can be performed. However, it takes effort and work that the ship and helo side don't want to make. The mindset must be shifted.", Vest interview.

Conry, former commanding officer of Battalion Landing Team 2/4 with the 24th MEU stated that, "We pay a price to do combined flight ops on one deck. Now with only three Amphibious Readiness Groups, it makes it even more complicated, trying to do too much with one platform; Helo ops, Harrier ops, well deck ops, etc."[72] Analysis of actual deployments and years of experience demonstrate that integrated STOVL jet and assault helicopter operations from L-class platforms are feasible and operationally compatible.[73] Creative scheduling and flight deck handling can allow for composite operations, but it does not optimize the use of either platform.

The challenge for the Amphibious Task Force and MAGTF commander is determining how to best optimize these assets to fit the situation at hand. This may mean, for example, off-loading all the jets to optimize the flight deck for helo ops to conduct a Non-Combatant Evacuation Operation when a carrier battle group is present to provide fixed-wing support. Sometimes, depending on the mission and availability of Joint TACAIR, the small fixed-wing STOVL det simply is not needed.

The real nature of the problems faced by fixed-wing TACAIR operating off of L-class ships is that the Navy owns the resources required to get to the battle and sustain the fight. Doctrinally, they are a position of control and "their concurrence must be obtained before one tap is turned. Failure to do so or action that incurs their wrath will surely end with a deaf ear turned toward your initiative."[74] As stated in VMA-331's After-Action report, this has some large implications.

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[72] Kevin A. Conry, Col, USMC, Director, USMC Command and Staff College, interview by author, 20 December 1996.

[73] Center For Naval Analyses, *Validation of AV-8A Employment During the Deployment of MARG 2-74*, Study, CNA 3020-75, 1 August 1975, 68.

[74] VMA-331 Desert Shield/Desert Storm After-Action Report, VMA-331, MCAS Cherry Point, N.C. 1991.

> First, the CATF is not held accountable by anyone to support the CLF's scheme of maneuver unless the CATF chooses to do so. This was witnessed by VMA-331's *Nassau* deployment time and time again. The Navy has the "high ground." This situation is not unlike that encountered by any Carrier Air Wing embarked prior to organizational changes brought about by the 1982 Beirut fiasco. The ship's Captain was just that, senior by one pay grade to the Commander Wing (CAG), and the CAG's next superior in his chain-of-command. Any tactical plan was inevitably overshadowed by the demands of the ship. The Navy's solution was to elevate the CAG to equal rank and make both commanders directly answerable to a common superior, the Commander Carrier Group. The "Super" CAG was responsible for successful mission accomplishment with the ship's Captain responsible for supporting the plan. The solution is similar to a typical USAF installation. Secondly, the "Gator Navy" is not comprised of war fighters in the context utilized by the Marine Corps. Employing an LHA outside of the typical MEU/composite squadron mode should and did create problems with respect to change. Employing 20 aircraft whose sole mission in life is warfighting/attack, demands exploring areas where the "Gators" just don't want to go.[75]

The Harrier is most productive on ship when used in the STOVL mode versus being forced to perform a vertical takeoff due to limited deck space. A normal mission involves a short takeoff followed by a vertical landing at the end of the mission when the aircraft has expended its ordnance, burned most of its fuel , and has the thrust-to-weight ratio required for a vertical landing. A Harrier is simply not going to get airborne with any substantial load of fuel and ordnance in a pure vertical takeoff. For every foot of deck roll and knot of wind over the deck, the payload increases substantially. All shipboard combat operations by USMC Harriers in Desert Storm involved a Short Takeoff (STO). Vertical takeoffs are performed on ship only for maintenance checks and airshows. The JSF is going to operate in the same manner off of ships. It could perform a pure vertical takeoff but with a huge resultant penalty in payload. The most effective means of takeoff for STOVL jets utilizes a ski jump.

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[75] VMA-331 Desert Shield/Desert Storm After-Action Report. CATF is Commander Amphibious Task Force, and CLF is Commander Landing Force.

"The most significant contribution that the Navy could make to STOVL air and helicopter-borne power projection is adding a ramp (ski jump) to all Tarawa- and Wasp-class amphibious ships."[76] It is ironic that although the US is the largest operator of Harriers and amphibious ships in the world, it is also the only navy in the world that does not have ramps on its Harrier platforms. The UK, India, Italy, and Spain all have ramp-equipped ships that optimize the combat power of the Harrier. The British discovered that if the ship's deck were curved upward the last 100 feet or so, the aircraft would exit the bow with a ballistic trajectory (speed builds up during the ballistic portion of the flight until the aircraft attains normal wing-borne flight). The US Navy studied ship designs featuring ski jumps with exit angles of up to 12 degrees but rejected the concept as too costly in design weight of the ship and perceived loss of helicopter spots.[77] The ramp for Harrier operations significantly improves aircraft performance, payload, safety, and deck utilization. A ramp not only dramatically improves a STOVL aircraft's takeoff performance, it facilitates concurrent fixed-and rotary-wing operations afloat.[78]

A STOVL aircraft does not require a catapult to operate at sea. After a short full-power deck run, the pilot vectors the thrust downward as he approaches the ship's bow. He then transitions to conventional flight by vectoring thrust aft and accelerates. The basic principle of ramp technology is that because the aircraft is imparted a ballistic trajectory, it can exit the deck at a lower speed and a higher gross weight than would be possible with a flat deck. For certain takeoffs, the ship need not steam at high speed because the ramp provides an effect equivalent to additional wind-over-the-deck (WOD).

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[76] Meyers, 6.

[77] U.S. Marine Corps, *U.S. Marine Corps AV-8 V/STOL Program, Fourth Edition* (GP32-0504, 1 April 1994, 2-17.

Tests indicate that ramps reduce WOD requirements by 10-20 knots.[79] The aircraft can also leave the ski-jump at any point in the ship's pitching cycle because the upward trajectory cancels the effects of the bow-down part of the cycle. The former Soviet Navy recognized the advantages of ramps in adapting MiG-29 and Su-27 aircraft (high thrust-to-weight fighters) for carrier operations; the Soviets kept the arresting gear to bring the aircraft aboard but installed 12 degree inclined-ramps for takeoffs.[80]

The heaviest Harrier launch ever--31,000 pounds--from the deck of any ship was from the ramp-equipped Spanish *Principe de Asturias* with a deck run of only 400 feet. "An aircraft whose weight precluded its launch from any LHA or LHD, even using the entire deck, used the ski jump to take off in approximately one-half that distance."[81]

Skeptics who insist that ramps will displace helicopter landing spots are wrong. "On a 12 degree ski jump approximately 150 feet long, the slope gradually increases from zero up to 12 degrees at the bow. The first half of the ski jump has a slope no greater than that of an LHA during wet-well operations with the well-deck flooded--both Harriers and helicopters can land on it."[82]

Ramps also provide a margin of safety to the pilot in takeoff emergencies. The upward vector off the bow offers the pilot extra precious seconds to handle takeoff emergencies and an expanded ejection envelope if required. Major (now Lieutenant

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78 Meyers, 6.

79 George E. Jessen , Rear Admiral, US Navy Ret, "The Ski Jump Is the Future," *Proceedings,* September 1995, 33,

80 Jessen , 32,

81 Major Art Nalls, USMC, "Why Don't We Have Any Ski Jumps?," *Proceedings,* November 1990, 81.

82 Nalls, 81.

Colonel) Meyers believes that the price of one saved STOVL aircraft would probably fund several ramps on amphibious ships.[83]

The Marine Corps will not be able to realize the maximum capability of the JSF flying off amphibious ships without a ramp. If the Navy/Marine Corps team is truly committed to operations in the littorals and the OMFTS concept with an emphasis on sea based fire support and logistics, then it needs to re-examine the merits of configuring L-class ships with ski jumps to optimize it's most lethal fire support asset: the JSF.

Concerns over the professionalism and quality of flight operations onboard amphibious ships as compared to CVs has generated much interest. In 1995 Major General Paul A. Fratarangelo, CG 3d Marine Aircraft Wing, wrote a message to Lieutenant General Anthony C Zinni, Commanding General of the I Marine Expeditionary Force, concerning the aviation mishap rate on amphibious ships. In this message, Major General Fratarangelo said:

> I am convinced that any objective observer would conclude that the carrier operating environment is more aircrew friendly that (sic) the amphibious operating environment. For example, from an aircrew perspective, the carrier capt/air boss team is (usually) more capable, effective and supportive than the amphib capt/air boss team. Carrier operations are governed by more comprehensive and user friendly SOPs than amphib operations. All carriers have adequate shipboard lighting, surveillance and approach radars and NAVAIDS. Adequate wind over the deck (WOD) is a near religion aboard carriers, whereas it often appears to be a non-consideration aboard amphibs. Aviation supply and logistics support is more robust aboard carriers, etc., etc.[84]

Unlike an aircraft carrier, current manning of the LHA and LHD Air Department does not allow for 24 hour flight operations for any extended period. Both surge and sustained capabilities on amphibious ships are limited due to the manning levels, thus

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83 Meyers, 8.

84 Commanding General, 3rd Marine Aircraft Wing e-mail to Commanding General, I Marine Expeditionary Force, subject: "Aviation Safety--The Next Level," 8 March 1995.

negating some of the capability of the Harrier and potentially the JSF. Air department manning is nowhere near that of a CV. This is oftentimes overlooked by commanders, resulting in unrealistic taskings and potentially unsafe operations.[85]

The ability to project power from the sea is still linked to the capability to effectively and safely launch and recover aircraft from ships.[86] "Even though the *Wasp*-class LHD offers vast improvements over the LHA in many areas to include command and communications, no improvements were made to the launch and recovery capabilities."[87] According to a 1995 memo from the Marine Aircraft Group 14 Safety Officer the issue of inadequate L-class (amphibious) ship recovery systems has been identified previously by the Harrier community via multiple hazard reports and during System Working Groups since early 1992.[88] Recovery systems currently in use on all L-class ships except the USS *Wasp* provides carrier controlled approach talk down capability only, is generally unreliable and performs poorly in bad weather. The memo also says, "With a strength of the MEU (SOC) being its ability to fight at night, it is essential that its platforms be able to provide adequate support for the conduct of safe night flight operations."[89] If more emphasis is not placed on properly equipping amphibs for 24 hour flight ops and providing more priority to flight operations, the operational capability and safety of the JSF will be compromised, just as for Harriers now. The USMC embarked mishap rate during Fiscal Year 1995 was 14.14, eight times as high as

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85 Jones, 17.

86 Vest, Kevin S., Major, USMC, *Not Capable of Doing the Mission: Launch and Recovery Systems Aboard L-Class Ships,"* Military Issues Paper (Quantico, Va: USMC Command and Staff College, April 1997), 1.

87 Vest, *Not Capable of Doing the Mission: Launch and Recovery Systems Aboard L-Class Ships,* 3.

88 Director of Standardization and Safety, MAG-14 memo to Director of Standardization and Safety, 2nd MAW, subject: "Comments on MajGen Fratangelo's E-Mail," 15 March 1995.

the ashore rate of 1.7. In 1995 the AV-8B had two embarked class A mishaps, while flying approximately 6000 embarked hours which works out to a 33.3 rate per 100,000 flight hours.[90] These numbers are unacceptable and we can not afford to lose JSFs at the rate with which we lose Harriers.

The approach and final control capabilities of L-class ships is lacking. L-class ships cannot accurately locate aircraft with the SPN-43 air traffic control radar nor can they reliably control them with their SPN-35A approach radar.[91] The SPN-35 final control radar cannot use the aircraft's IFF or altitude reporting, does not work in rain, and is difficult for the operator to use. Numerous reports have recorded both the system routinely going down and improper handling of air traffic by ships controllers. "Although the shortcomings associated with the current L-class ship electronic landing aids have been acknowledged for nearly two decades, only recently have programs been funded to try and improve the situation."[92] Funding was provided to upgrade the reliability and maintainability for the SPN-35A precision approach radar, but this upgrade will not improve performance in foul weather or correct any other shortcoming except for parts availability.

> The SPN-35A upgrades are a stop-gap measure until all LHA and LHD-class ships can be retrofitted with SPN-41A radars. The SPN-41A is the old precision approach radar...being phased out on all of the carriers as they are replaced by the more advanced SPN-46 series radars. The SPN-41 radar allows a pilot to fly an instrument landing system type approach without talking to a controller...Because

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89 Director of Standardization and Safety memo.

90 USMC Embarked Mishap Rates, VSTOL Operational Advisory Group 1995, item OAG95-401, October 24 1995.

91 Vest, *Not Capable of Doing the Mission: Launch and Recovery Systems Aboard L-Class Ships,* 5.

92 Vest, *Not Capable of Doing the Mission: Launch and Recovery Systems Aboard L-Class Ships,* 6.

the SPN-41 is being phased off the big deck carriers, long term SPN-41 supportability and availability is questionable.[93]

Precision fixed-wing operations cannot be conducted with these old systems and procedures. The tactical jet shipboard environment requires reliable launch and recovery aids in all weather, day and night. A CV radar can monitor aircraft in all quadrants and can pick-up aircraft .25 to .5 miles off of the catapult. L-Class ships have blind areas in their radar coverage which includes the quadrant in which Harriers are normally expected to rendezvous in after departure.[94] The equipment used to recover aboard carriers is not compatible with the launch and recovery systems aboard L-class ships.[95] L-class ships with STOVL jets on board must meet the same standards as the carriers.[96]

The lack of Day/Night capable L-class shipping has historically prevented the fleet from timely training of pilots and Landing Signal Officers (LSOs). Priority for Carrier Qualifications still hamper L-Class ship availability. Competing demands such as well deck ops and general ship training during reduced at sea time due to reduced funding limit the time available for flight operations.[97]

Current night refly requirements on L-class ships does not ensure that pilots maintain proficiency.[98] The CV LSO Naval Air Training and Operating Procedures

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93 Vest, *Not Capable of Doing the Mission: Launch and Recovery Systems Aboard L-Class Ships,* 7.

94 Vest. Major Vest's information concerning carrier capabilities and flight-hour program was received through telephone conversations with LSOs from Carrier Air Group (CAG)-11, CAG-14, and CAG-9.

95 Vest, *Not Capable of Doing the Mission: Launch and Recovery Systems Aboard L-Class Ships,* 11.

96 L-Class Ship Radar, VSTOL Operational Advisory Group 1995, item OAG95-402, October 24 1995.

97 AV-8 CQ Ship Availability, VSTOL Operational Advisory Group 1995, item OAG95-404, October 24 1995.

98 Major Vest stated that work is being done to correct this. The latest edition of the VSTOL LSO NATOPS prohibits using any landing within the first 30 minutes after sunset for qualification/currency. Vest interview.

Standardization Program (NATOPS) is more restrictive than the VSTOL NATOPS. The CV LSO NATOPS require flight operations to be within divert distance if more than 15 days have lapsed since a pilot's last night landing. On L-class ships it is 30 days. Competing requirements can force flight operations to start early enough so that night operations are not possible. When this stretches to the 30 day limit, proficiency for both the pilot and ships flight operations personnel, especially Air Traffic Control, is low. Embarked pilots need the constant practice to maintain their skills.[99] A "good" cruise would give the average Harrier pilot about 13-15 hours of flight time per month embarked. Normally, Harrier pilots fly as little as 8 hours per month at sea, and get the majority of their flying and tactical training when based ashore during deployments. This average has not changed since the very first six month deployment of AV-8As on the USS *Guam* in 1974. A Harrier validation study of that initial cruise stated that "With the limited flying opportunities during the six month deployment, the pilots did not consider their proficiencies adequate for safe flight during marginal weather at night."[100] The Harrier flight time average has been historically low as compared to tactical jet pilots flying off CVs. The carrier aircraft with the mission most comparable to the Harrier is the F/A-18 Hornet. USN Hornet pilots average 25-30 hours per month at sea. The Navy funds the Hornet flight hour program for 25 hours per month for each pilot. They fund for 115% while at sea to ensure the maximum amount of flying is done while at sea versus ashore.[101] The Navy knows that their bread and butter is sea-based aviation

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[99] Pilot Proficiency Underway, VSTOL Operational Advisory Group 1995, item OAG95-405, October 24 1995.

[100] Center For Naval Analyses, *Validation of AV-8A Employment During the Deployment of MARG 2-74*, Study, CNA 3020-75, 1 August 1975, 37.

[101] Mark K. Hunter, LCdr, USN, and Kevin S. Vest, Major, USMC. LCdr Hunter is a USN F/A-18 pilot who provided information concerning average flight hours aboard carriers from his personal flight log

power. If the Marine Corps is going to be committed to making OMFTS work, then sea-based airpower will assume an even greater importance and we need to emphasize that over basing our aircraft out of airfields with 8,000 foot long runways. Flying tactical jets around either amphibs or a carrier is similar and there should not be any major discrepancies between the two.[102]

If we envision maintaining a primarily sea-based approach to conducting operations and we need responsive air support day and night, in all-weather conditions, then we need to fundamentally change how we operate fixed-wing jets off amphibious ships. A JSF pilot flying 8 hours a month at sea will probably not be very proficient in CAS and interdiction, much less other missions that may be required such as anti-air warfare, anti-surface warfare, or MV-22/helo escort while also maintaining proficiency in flying precision night approaches in marginal or poor weather. If reduced flight hour on amphibious ships will remain a fact of life due to conflicting demands or lack of flight hour funding, then reliable, user-friendly precision instrument approach systems in the JSF, coupled with state-of-the art shipboard radar and approach systems would help to ensure a safe and predictable means of recovering back aboard the ship, regardless of pilot proficiency.

All aircraft operating off of amphibious ships are configured for Night Vision Goggle (NVG) operations (the only exception is the older day-attack AV-8B), which allows these aircraft to conduct NVG shipboard launch and recovery operations.

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books that covered two cruises. LCdr Hunter averaged 25 hours per month with 11 hours of night time per month. Vest's information concerning the carrier flight-hour program was received through telephone conversations with LSOs from Carrier Air Group (CAG)-11, CAG-14, and CAG-9, interview by author, 4 April 1997.

[102] LHA and CV NATOPS Comparison, VSTOL Operational Advisory Group 1995, item OAG95-406, October 24 1995.

Currently, due to safety concerns, neither the AV-8B or F/A-18 conduct NVG launch or recovery operations, although they are entirely capable of doing so. In the case of AV-8Bs, extensive coordination is required when attempting to conduct simultaneous NVG helicopter and unaided fixed-wing night flight operations. Currently, fixed-wing and helicopter night shipboard flight operations must be conducted separately because the use of NVGs requires the reduction of ship lighting to a level compatible with the NVGs while current AV-8B night shipboard ops require that all ship flight deck lighting be functioning. The transition from dark to light only takes minutes but the reverse may take 10-15 minutes as lights are reduced and re-adjusted to match the ambient level.[103] Once qualified, the safer mode for night operations for helicopters is utilizing NVGs due to the overall enhancement of pilot situational awareness. To enhance the capabilities of the JSF, improvements over current NVGs and policy must be sought to allow for NVG shipboard recovery.[104] This would increase safety and standardize the recovery of all MAGTF aircraft onboard amphibious ships. Endorsements of a recent AV-8B mishap at sea have demanded that the NVD launch and recovery capability be developed.[105]

The most potent and effective method of employing the JSF onboard L-class ships is to place a squadron or two (based upon the number of JSFs assigned to each squadron) on one large deck and designate this ship a dedicated fixed-wing tactical platform. This concept, currently known as a "Harrier Carrier", has been proven to be the most effective means of maximizing the firepower and surge capability of STOVL jets when operating off of amphibious ships. In August 1990, VMA-331 embarked an entire

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103 VMA-331 Desert Shield/Desert Storm After-Action Report.

104 Barnhart, 14.

squadron of twenty AV-8B Harriers on the USS *Nassau* for an eight month cruise in support of Desert Shield/Desert Storm. Also onboard were six UH-1Ns, and three AH-1Ts. Unlike the experience and team mentality on CVs, neither the Amphibious Group 2 staff nor the 4th Marine Expeditionary Staff possessed any inherent expertise in joint TACAIR planning. This manifested itself in assumptions about the role of the AV-8Bs aboard the *Nassau,* typified by a "go-it-alone" mentality.[106] Once it had been determined that the 4th MEB's mission was to prepare for an assault from the sea, the ineptness of the staff in properly projecting the needs of 20 fixed-wing jets was apparent. This was manifested in a predilection to be at anchor, unrealistic anchorage positioning, and a flight quarters program that emphasized the Nassau's desires versus the tactical training and preparation of aircrew.[107] The old axiom of "you fight like you train" haunted VMA-331's every operational thought.[108]

The LHA worked well during Desert Storm as a dedicated AV-8B "forward base." The best method to integrate help ops while attempting to maximize AV-8B ops was to write, and stick to, a schedule using hard takeoff and flexible (flex deck) recovery times. However, for maximum surge rate sorties, a true "flex deck" concept was proven workable as long as the LHA was dedicated solely to supporting the AV-8B. The VMA-331 *Nassau* deployment proved that during combat operations, the "Harrier Carrier" concept was valuable as a stand alone force or as an effective augment to the CVBG. It

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105 NVD Operations for AV-8s on L-class Ships, VSTOL Operational Advisory Group 1995, item OAG95-403, October 24 1995.

106 VMA-331 Desert Shield/Desert Storm After-Action Report.

107 VMA-331 Desert Shield/Desert Storm After-Action Report.

108 VMA-331 Desert Shield/Desert Storm After-Action Report.

also showed, once again, how difficult it is to effectively integrate fixed-wing flight ops with all the other missions the LHA is tasked with.[109]

If a dedicated "Harrier Carrier" is developed for the Harrier, such as an LHA/LHD with a ramp and updated radars, it would serve as the optimum mobile forward base. "Two STOVL JSF squadrons (perhaps 32-36 aircraft) could potentially *double* the offensive strike capability of a single carrier. On a dedicated fixed-wing STOVL amphibious deck all sorties committed to offensive air support, the LHA or LHD's *offensive* sortie generation rate would match or exceed that of the carrier's."[110] If integrated helo, surface, and fixed wing ops continue from the same platform, the full combat potential of the AV-8B or JSF will never be realized while operating from sea platforms. The "Harrier Carrier" concept is not considered viable when simultaneous helo functions are competing for the flight deck.[111] The same problems will plague the employment of the JSF on L-Class ships.

Forward Basing. Basing reductions could lead to scenarios where the US does not have a land base within range of a given operation, leaving its forces with two options. US forces could operate from ships, or they could take a sector of land by force and set up an operating strip.[112] If we are going to optimize the expeditionary employment of the JSF we have to realize our current limitations and develop the doctrine and equipment to support an expeditionary concept which includes land basing aviation when practicable.

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109 VMA-331 Desert Shield/Desert Storm After-Action Report.

110 Meyers, 9.

111 VMA-331 Desert Shield/Desert Storm After-Action Report.

112 Avance and others, 43.

In Desert Storm, the vast majority of Coalition aircraft had to fly extended distances and operate in conjunction with other aircraft from distant bases. The flight distances made aerial refueling a must for most combat missions. *The Gulf War Air Power Survey* stated that the "closest land or carrier basing put aircraft 175 or more miles from the nearest targets in the Kuwait theater and more than triple that distance for targets in the Baghdad region."[113] The bulk of the combat aircraft flew from bases in southern Saudi Arabia and the coastal Gulf states. Targets for these aircraft and the Red Sea carrier aircraft were 700 to 1,000 miles away, well beyond the unrefueled combat radius of most aircraft.[114] This statement in the *Survey* ignored USMC Harriers operations from a forward site, capable of hosting 12 AV-8s, established at the ARAMCO helicopter field of Tanajib south of the Kuwaiti border, putting the jets within 40 miles and five minutes flying time from the battle.[115] These Harriers were the most forward deployed tactical jets in theater. Average Harrier turnaround time during the ground war surge rate flight operations was 23 minutes.[116] The Harrier also flew all of its missions without any requirement for in-flight refueling. Forward basing, either at sea or ashore would possibly eliminate any requirement for tactical air refueling for the JSF. This is especially critical for a MEU that currently has no organic air refueling capability at sea.

The Marine Corps likes to extol the virtues of the STOVL aviation concept and it prints a lot of material that seemingly supports the entire concept. However, very few

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113 Thomas A. Keaney and Eliot A. Cohen, *Gulf War Air Power Survey Summary Report,* (Wash. D.C.: US GPO, 1993), 167.

114 Keaney and Cohen, 167.

115 U.S. Marine Corps, *U.S. Marine Corps AV-8 V/STOL Program, Fourth Edition* (GP32-0504, 1 April 1994, 2-11.

Marines truly understand the STOVL employment concept, the requirements to make it successful, and its limitations. The VMA-331 Desert Storm after-action report states that "The Marine Corps as an institution, has been committed to the concept of forward basing of fixed wing aircraft since 1971. Even so, the ranks of the officer corps is wholly ignorant of the VSTOL concept, how to effectively employ it, what it takes to support it, and how to plan for it.[117]

Forward basing tactical aircraft will reduce the distance to the battlefield and enemy targets, improves response times, and aircraft surge rates. Dispersal gives you options and also eases the range constraints that STOVL aircraft operate under. Dispersal for survival is a natural fallout from the flexibility in basing both afloat and ashore.[118] But the difficulty of dispersion to forward sites is the problem of command and control and logistics. Aircraft have a constant demand for fuel. And if you want to use the aircraft in combat, you need to be able to supply it with ordnance, spare parts, maintenance support, water and food for the troops, and security or force protection. Operating jet aircraft from dispersed sites is a big logistical challenge. Even the Marine Corps concept paper on OMFTS acknowledges that "the requirement to sustain fast-moving, powerful, combined arms forces conducting ship-to-objective maneuver will strain the best logistics system."[119]

Marine aviation requires large quantities of fuel, ordnance, and spare parts to maintain aircraft and support equipment. Major Mark Jaffry wrote in a concept paper for

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116 United States Marine Corps FactFile, "AV-8B," downloaded from the *World Wide Web*, http://www.usmc.mil/factfile/219e.htm, 29 October 1996.

117 VMA-331 Desert Shield/Desert Storm After-Action Report.

118 U.S. Marine Corps, *U.S. Marine Corps AV-8 V/STOL Program*, 2-5.

119 *Operational Maneuver From The Sea*.

MAGTF Air Operations that supplies required during the initial stages of an operation from the sea will come from supporting ships. However, the ability to resupply both fuel and ordnance quickly must be considered as both ship to objective distance and tempo of operations increase. In addition, the resupply system must have the mobility to keep up with the landing force as it conducts maneuver warfare toward its objective.[120]

During an amphibious assault, initial aircraft operations ashore will normally be flown from a forward site. The site, located in secure area out of enemy artillery range, is used as a turnaround or ground loiter station. According to current Marine Corps doctrine, Forward Arming and Refueling Points (FARPs) are temporary, transitory in nature, and are established for a specific mission. The ultimate objective of the FARP is to minimize flight time to and from the primary refueling and arming area. This is accomplished by locating the FARP as close to the objective area as analysis of the mission, enemy, time, space and logistics allow. Support of the FARP should be minimized to the greatest extent possible. Normal support required consists of fuel, ordnance, communications, and command element personnel. The ideal situation would be to have several small, dispersed sites, supportable by combat service support elements, and capable of supporting small detachments of aircraft.[121]

A forward site enhances response time. It is suitable for a fully loaded and armed aircraft to land and ground loiter awaiting a mission, either preplanned or on call. Ideally, fuel and ordnance would be staged at this site and would be brought in by helos or, more preferably, by truck. However, the site would not routinely require logistics

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120 Mark E. Jaffry, Major, USMC, *A Concept for MAGTF Air Operations,* Concept paper draft (Quantico, VA: Concepts Division, MCCDC, 20 February 1997), 7-8.

121 Jaffry, 21.

support and would only require a minimum number of support personnel. Upon completion of a mission, aircraft would normally return to a main base or a ship for refueling, arming/dearming, and maintenance. Normally no maintenance will be performed at a forward site. Aircraft needing attention will be ferried to other installations or a maintenance team can be sent to the site. Operations from such a site are usually limited to day VFR operations.

The forward site concept was proven to be successful in combat during the Falklands campaign. Once the British ground forces were ashore in the Falklands, a 300 yard long metal matting runway was laid by Royal Engineers across an area of grass and peat. Flexible aviation fuel bags were placed in a line along the shore and fuel was pumped from there to the strip. Ordnance was stockpiled and the area was protected by Rapier anti-aircraft missile batteries. This site became a forward operating base that had been envisioned as part of the classic Harrier operating scenario.[122] Sea Harriers could now engage the enemy at full combat power for vital extra minutes, then land at the forward operating base (FOB) instead of having to conserve fuel for recovery aboard the carrier for refueling and re-arming. Harriers on ground attack sorties could also spend more time over the islands. The assault ships *Fearless* and *Intrepid* were also used as floating FOBs. The British had only the Harriers to provide fixed-wing support (having just previously removed from service the HMS *Ark Royal* conventional carrier with a wing of F-4 Phantoms embarked) and they were committed to making it work. The Marine Corps and Navy have not shown the same commitment, and may not need to if CVBGs or conventional land-based TACAIR is available.

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[122] Myles, 51.

According to the *U.S. Marine Corps AV-8 V/STOL Program* publication, an intermediate-size land base, or facility can also be established ashore. Such a base will normally have a runway of at least 1200 x 72 feet, and parking for six to ten STOVL aircraft. If existing facilities cannot be used a facility can be constructed with available embarked material and equipment flown in by helicopter. "An estimated 325 tons of equipment and supplies are needed to establish a facility."[123] This is certainly not a minimal footprint ashore and the 30 or more CH-53 helicopter sorties that would be needed to move this equipment ashore to base six to ten jets would severely hamper the ACE's ability to support any other operation within the MAGTF. Helicopters may be the most appropriate transportation mode for supporting bases ashore, but due to the heavy demand on helicopters within a MAGTF, their availability may be overridden by other priorities. OMFTS requires responsive right-time, right-place logistics support and MV-22s and CH-53s cannot be dedicated to building and supporting large, easily targeted air facilities.

A VSTOL Facility Installation Equipment Summary chart in the *V/STOL Program* publication shows that to build the facility from scratch would require 1,234 tons of equipment (117 trailer loads) that would need to be brought ashore.[124] The most desirable deployment of VSTOL aircraft ashore is from a main base. This would normally be an existing, available airfield where VSTOL aircraft could operate along with conventional aircraft in order to reduce the logistics train. A facility could also be upgraded to a main base. If neither is possible or desirable, and logistics permit, a main base can be constructed from embarked matting assets. Approximately 880 tons of

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123 U.S. Marine Corps, *U.S. Marine Corps AV-8 V/STOL Program*, 2-24.

equipment and supplies will be necessary to establish a main base. Support for operations at a main base can be anticipated to require 32 powered and 18 towed vehicles, and up to 14 powered and 8 towed vehicles at a facility.[125] This would entail an enormous logistics operation to build and support and is virtually not feasible with OMFTS.

The Corps' most recent enhancement in the Expeditionary Airfield (EAF) program is EAF 2000. The EAF 2000 Airfield consists of a 3,840-foot by 72-foot runway, various taxiways, and parking areas. The entire field may be assembled in 18 to 30 days dependent upon the earthwork necessary to prepare the site. This airfield is designed to support 75 tactical aircraft or assault support helicopters and three KC-130s. Each Marine Aircraft Wing has the assets available, within the existing inventory, to install two EAF 2000 airfields and six Vertical/Takeoff and Landing (V/TOL) pads. A V/TOL pad is a 96-foot by 96-foot mat expanse used for rotary wing and AV-8B aircraft.[126] The Barebase Airfield is another expeditionary airfield concept within EAF 2000. Under this concept, an existing paved area such as an abandoned or captured runway, stretch of highway, or large parking lot may be converted into an airfield by outfitting it with equipment such as AM-2 matting. This airfield is flexible in dimensions and is designed to outfit an existing runway. Capability to construct 900-foot barebase configurations are also available in the inventory.[127] Major Meyers advocates installing ski jump ramps on an EAF to decrease its length to less than 2,000 feet, yet still

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124 U.S. Marine Corps, *U.S. Marine Corps AV-8 V/STOL Program*, Figure 2.30, 2-25.

125 U.S. Marine Corps, *U.S. Marine Corps AV-8 V/STOL Program*, 2-27, 2-31.

126 *Expeditionary Airfields Information Paper*, Aviation Branch, Headquarters USMC (Washington, DC: Aviation Branch, HQMC, ASL-45, 8 August 1994), 1.

127 *Expeditionary Airfields Information Paper*, 1-2.

providing a maximum gross takeoff weight capability to STOVL aircraft.[128] Ramps could also provide almost limitless EAF locations wherever there is a quarter-mile stretch of road or highway. Smaller EAFs provide several advantages.

> A reduced footprint makes it less susceptible to targeting and the chance of being hit. Reduced construction time, especially when a road or highway is used as the runway, maintains operational tempo. They are more easily relocatable when the mission dictates. They are easier to camouflage and defend because of their size and ideally their location."[129]

Due to the increased emphasis on low intensity conflicts, there is a greater need for rapid deployment of EAF equipment. The Maritime Prepositioned Force (MPF) will provide this support. Currently, there is enough EAF equipment on each Maritime Prepositioned Squadron (MPS) 2 and 3 to support 11 AV-8B aircraft or helicopters. When additional space becomes available on the MPF, EAF assets will be embarked to provide an entire EAF 2000 airfield on each MPS.[130] While AM-2 matting has been a versatile surface material for expeditionary fields, it's excessive weight and bulk create a logistics footprint that is difficult to support. Because of its high weight and cube, transportation requirements, installation time, and personnel injury associated with its installation are high. A lightweight, reusable matting is required to reduce the logistics footprint, installation time, and the installation injuries associated with AM-2 matting.[131]

The Marine Corps cannot expect to deploy around the world building the EAF 2000 at will. It should re-embrace the following criteria for FOBs established back in 1956 based on lessons learned during WWII and Korea:[132]

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128 Meyers, 11.

129 Meyers, 11.

130 *Expeditionary Airfields Information Paper*, 2.

131 USMC Concepts Branch, *Mission Needs Statement For Lightweight Reusable Expeditionary Airfield (EAF) Matting,* Draft (Quantico, VA: Concepts Branch, MCCDC, 1997)

132 United States Marine Corps, *Aviation Ground Support.*

1. Small, quickly constructed tactical support airfields of a temporary nature to accommodate at least one squadron.

2. Ready to use in the first three to five days of an amphibious assault.

3. Usable for 30 days to support the landing force in tactical operations ashore.

Major considerations of the time required airbase size to be limited by time allowed for construction, restricted to existing sites that could quickly be restored, or unprepared sites needing a minimum of development. The advent of high performance aircraft saw the Corps expand from these criteria to large expeditionary airfields with enormous logistical footprints. The Corps should once again move away from large, cumbersome, easily targeted airfields and focus on developing and utilizing forward sites and FARPs. The goal is to remain as small as the operation permits and only build in capability that an operation demands.[133]

Forward operating bases would have to be protected from both air and ground attack and the vehicles and lines of communications to support these dispersed sites would be vulnerable to attack and disruption. Currently there are more than 20 non-NATO countries which possess a theater ballistic missile (TBM) capability and most of these countries are in the littoral regions of the world.[134] Because TBMs are considerably cheaper than modern fixed-wing aircraft, more countries will look to them as a viable means of defense. In order to counter this threat, the Marine Corps will require a mobile, multi-role weapon with greater lethality capable of defeating both TBMs and aircraft.[135] Critics who point to the premium which must be paid "ignore the bonus this dispersed

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133 Jaffry, 22.

134 Jaffry, 22.

135 Jaffry, 22.

operation provides to any commander: flexibility, surprise, and most important, survivability."[136] The OMFTS concept should reduce our vulnerability. "With vastly smaller numbers of men and machines ashore, helicopters, V-22s, and LCACs can deliver supplies from ships directly to the using units, instead of creating large dumps that become a target to be protected."[137] Building or occupying large airfields or FOBs would increase our vulnerability to attack and reduce our flexibility. Protecting forward bases becomes more complicated with an enemy that fights us asymmetrically or has the ability to use long range ground-to-ground missiles. Modern guerrillas and terrorists also avoid conventional battle and instead attack soft targets, such as rear-area installations.[138]

Basing fixed-wing TACAIR ashore can be a huge engineering and logistical undertaking. USMC land-based flight operations in Operation Desert Shield/Desert Storm required enormous engineering support. Lieutenant General Royal Moore, commander of Marine air in Desert Storm said:

> We did have some very good facilities but we outgrew them very quickly. The SeaBees helped us lay in excess of three million square feet of AM-2 aluminum matting all over the place. The F/A-18s and A-6Es had it down at Shaik Isa, and we housed five AV-8B squadrons plus OV-10s on the mat at Jabayl. We built a spot for a whole helo group. At Tanajib we did the same thing. We went out to Lonesome Dove, which was 145 miles out in the desert, and we built three fields for the CH-46s and Ch-53s, and the SeaBees and Marine Wing Support Squadrons and logistics personnel put that together.[139]

All of the general-support engineering for Marines in Desert Shield/Desert Storm came through the combined efforts of two Marine engineer battalions and one SeaBee regiment. The primary engineering effort was to improve the existing runways in the

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136 Myles, 195-196.

137 Hoffman, 32.

138 Hoffman, 29.

139 Interview with LtGen Royal N. Moore, Jr., USMC, "Marine Air: There When Needed", *Proceedings*, 63-70. 67.

region that lacked aprons and parking areas "to make the airfields fully capable of supporting tactical operations."[140] Major Robin Gentry, USMC Studies and Analysis Division, says that Marine Wing Support Squadrons have lost 50% of their personnel strength since Desert Storm and can no longer construct expeditionary airfields, they can only maintain them. We need SeaBees to build them.[141]

Even building up existing facilities can take time and personnel that the Marine Corps may not have in future operations. Marine Wing Support Squadron-174 had 526 Marines and sailors, plus 137 sailors (Seabees) of Navy Mobile Construction Battalion (NMCB)-4 supporting Marine Aircraft Group-13 at King Abdul Azziz Naval Air Station in the Gulf War. These Marines and sailors, working under near-ideal conditions and with no interference by the enemy, took two months to build up sufficient taxiways, parking, and landing pads with AM-2 matting to the *already existing runway* in order to provide room for MAG-13's 55 Harriers and 20 OV-10 Broncos.[142] Even at the Harrier and helo "forward site" at Tanajib, the expansion of the existing airfield's infrastructure was a large project. Seabees from NMCB-40 laid a 1,750,000-square-foot AM-2 helicopter parking area on a base of 200,000 cubic yards of soil, built a 1,600-foot taxiway, concrete pads for clamshell hangers, a 60,000-square-foot maintenance hardstand, and a 9-module aviation ammunition supply point.[143] This forward site is much more extensive and required a lot more manpower and materials to build then what

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140 Interview with BGen James A.Brabham, USMC, "Training, Education Were the Keys", *Proceedings*, November 1991, 51-54., 52.

141 Robin Gentry, Maj, USMC, Analyst at USMC Studies and Analysis Division, interview by author, 4 September 1996.

142 Steven M. Zimmek, Major, USMC Ret., *U.S. Marines in the Persian Gulf, 1990-1991 A War Of Logistics: Combat Service Support in Desert Shield And Desert Storm,* Unpublished Draft. 27 December, 1996, 2-14 to 2-15.

143 Zimmeck, 4-23.

is stated in doctrinal publications.[144] The Marine Corps has yet to prove that we can *quickly* establish forward sites in a hostile environment in actual combat conditions, much less in one to two days as stated in the *U.S. Marine Corps AV-8 V/STOL Program* publication. We have done this for helicopter operations. Establishing FARPS for helicopters alone is a much simpler matter, and numerous helo FARPS were established in Desert Storm in one day.[145]

Major Hoffman advocates dispersing aircraft "on land in small detachments that make frequent shifts to new locations, greatly reducing the threat posed by weapons of mass destruction."[146] But the increased burden on Combat Service Support may overwhelm the system while attempting to provide right-time, right-place supply to both ground maneuver elements and shore-based aviation. A MEU will likely be unable to support sustained aviation ashore from austere sites that do not provide easy access or established infrastructure. A MEF will be more capable of supporting aviation ashore but we have not had to fight our way into a hostile area and build up our own infrastructure without established friendly port and airfield facilities and major host-nation support since the Inchon landing in 1950. The Marine Corps entered Southwest Asia through the heart of the most developed infrastructure in the Persian Gulf. This region contained major airfields and seaports interconnected by an extensive road network optimal for

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144 U.S. Marine Corps, *U.S. Marine Corps AV-8 V/STOL Program*, 2-18 to 2-21. Discussion of forward sites includes an illustration of a forward site (Figure 2.26) "which should take as little as five hours to build, but even if necessary to locate it in a rough or lightly forested area, it should be possible to have it operational within a day." The figure used to illustrate buildup requirements for a Forward Site (Figure 2.24) only shows material, manpower, and time required to build a 72 x 72 square-foot pad although the *Program* book states that 96 x 96 feet is preferable).

145 Zimmeck, 5-42. Zimmeck's book is replete with examples of FARPs being established and pushed forward to refuel and support 3d MAW's helicopters

146 Hoffman, 31.

joining Marines who arrived by air, with their surface-transported equipment.[147] Doing what we did in Saudi Arabia under near-ideal conditions and attempting to build-up comparable firepower ashore in a hostile and underdeveloped country is an entirely different matter.

USMC Captain John D. Schneider made some very strong arguments against the Marine Corps ability to adequately sustain forward based aircraft in an article about the rear area battle. Current Marine Corps doctrine calls for Marines from within the Air Wing to provide security for expeditionary airfields and forward sites. Every Marine a rifleman, right? But the Air Wing Marines are not organized, trained, or equipped to react quickly and decisively to an attack.[148] Schneider writes about current deficiencies in forward basing:

> Helicopters, AV-8Bs, and OV-10 Broncos can all operate from small, forward air strips--or can they? In reality, aircraft are tethered to an air field, and the tether is generally as long as the aircraft's unrefueled range....they are for the most part, confined to operating from a fixed base near their supporting units, because sustained maintenance requires tools, engine stands, and test equipment that cannot be moved easily to forward sites. Dispersal of aircraft for more than short periods is not feasible--you cannot split up already-limited amounts of equipment and numbers of maintenance personnel. Dispersing aircraft does not eliminate the need for security either; it simply makes the aircraft harder to locate and destroy in numbers.[149]

The vulnerability of FARPs and other forms of FOBs is well documented in the Marine Corps Lessons Learned System (MCLLS). Lieutenant Colonel Burkett, USMC, stated that the "limited ability to secure FARP and FOB continues to be a source of

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147 Zimmeck, 1-18.

148 John D. Schneider, Capt, USMC, "Some Realities of the Rear Area Battle," Proceedings, (Annapolis, MD., US Naval Institute, November 1991, 96-98), 96. Dr. V. Keith Fleming Jr., Marine Corps University, adds: The "Every Marine a Rifleman" myth has its value in maintaining morale, but it has caused enormous problems for wing units at the start of conflicts. The reality is that only in a short-term emergency can wing units defend themselves or provide security... No one can spend a 12-16 hour shift repairing aircraft and then go man bunkers. There will have to be ground units defending the bases..."

149 Schneider, 96-97.

concern. This is especially true as distances from ship-to-shore increase and the Aviation Combat Element becomes more of a maneuver element."[150] Burkett further states that mission accomplishment, both the specific mission undertaken and the MAGTF mission generally, is tied to a degree on the security and survival of the prepositioned ground logistics components of the FARP and FOB.

OMFTS envisions the ability to generate and sustain an operational tempo that will overwhelm our enemies. Any sustained operational tempo is going to require a lot of fuel. In a recent article in the *Gazette* concerning the Corps' ability to provide fuel in support of OMFTS, USMC Colonel Charles O. Skipper describes both past and present capabilities and makes recommendations to fix current shortcomings. During Desert Storm, the Marine Corps bulk fuel capability to support an OMFTS-type operation was summarized as follows:

In an amphibious operation, tank landing ships (LSTs) would utilize the Navy's amphibious assault bulk fuel systems to transfer fuel from ship to shore. Once the fuel arrived at the high-water mark, it would be received by the Marines of a bulk fuel company. The fuel was either pumped to large fuel farms or transferred to trucks for line haul or tactical distribution. The tactical airfield fuel dispensing system (TAFDS) of the MWSSs using 20,000-gallon bladders was used to store fuel at airfields and distribute the fuel to aircraft. M970, 5,000-gallon fuel trucks and were used to line haul fuel. 900-gallon, six module containers (SIXCONs) were also transported by the logistic vehicle system (LVS) to transport fuel to maneuver units.[151]

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150 Burkett, LtCol, USMC, "Marine Corps Lessons Learned System," #00443-81346, 7 September 1989.

151 Charles O. Skipper, Col, USMC, "Can We Fuel OMFTS?," *Gazette*, January 1997, 47-48.

The retirement of the LSTs has removed the capability to provide fuel support in an amphibious operation against an effective enemy. Navy planners talk of using commercial barges to bring fuel ashore since current amphibious ships do not have the shallow draft of the LST and cannot get in close to shore in many regions. Colonel Skipper questions the security of commercial barges against our enemies given the proliferation of artillery and fire-and-forget missiles. Another solution under consideration is to use Marine fuel trucks to shuttle fuel from ship to shore on LCACs. This may work in small-scale operations, but "our lean motor transport capability is needed ashore delivering fuel, not wasting transit time to and from over-the-horizon amphibious ships."[152] One final suggestion is to use MPF ships to pump fuel from ship to shore, however it is difficult to imagine doing this in the first 3-5 days of an amphibious operation with any coastal threat present.[153]

In Desert Shield/Desert Storm the Marine Corps did not have sufficient fuel transport trucks for subsequent operations ashore. From the beginning of the deployment, the Marines used host nation trucks and creative substitutions for ground transportation. The Saudi government provided forty-five 8,000 gallon tankers to move fuel to King Abdul Azziz Naval Air Station and Jubayl Naval Air Facility.[154] USMC helicopters and fixed-wing jets at Abdul Azziz and Shaikh Isa received fuel contracted from and transported by the host nations.[155] The Army provided tremendous line haul

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152 Skipper, 48.

153 Skipper, 48.

154 Zimmeck, 29.

155 Zimmeck, 1-30-1-31.

support to the Corps, "but that support will certainly not be available early in an amphibious operation."[156]

The Corps still does not have enough line haul equipment to transport significant amounts of fuel and ordnance. Major General Michael Williams, a former Commanding General of 2nd Force Service Support Group, stated that "Ammo is not light, it takes every piece of equipment and truck in the world to move it." He also said that "CH-53s aren't going to blacken the sky carrying in pallets of ammo, and they aren't going to do it in 15 years either."[157] The Marine Corps is purchasing 82 additional M970 5,000-gallon fuel trucks to improve line haul capability, but the M970 is not going to be able to go everywhere the Corps needs fuel (it is an on-road vehicle with limited tactical or off-road capability), and we still need to find a better capability to haul ammo to dispersed forward sites.

Hauling ammo to support a few attack helicopters is one thing, getting significant amounts of ordnance to a JSF is quite another. Logistics take up a lot of weight and space, and place an enormous burden on already limited vertical lift capability. In addition, relying on aviation to resupply forces ashore requires secure landing zones and fairly cooperative weather. Ground transportation is more reliable and less affected by weather, but trucks require open and secure lines of communication and are not as fast as helicopters.

One area where the Corps has made progress since Desert Storm is in our capability to use helicopters for fuel transfer. The CH-53E tactical bulk fuel delivery

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156 Skipper, 48.

system (TBFDS) is presently being fielded. This modular system consists of three ballistically proven, crash worthy, 800-gallon tanks that are designed to be carried internally by the helicopter. This system enables the host helicopter to use it to refuel in flight, provide on-the-ground refueling to other aircraft or ground vehicles, or replenish FARPs. Each CH-53E squadron will receive four systems. The fielding of TBFDS is a great capability and should be deployed with MEUs, utilized in training exercises, and receive as much exposure as possible so that we can fully exploit its capabilities.[158]

Although the TBFDS is an improvement in the Corps' ability to provide fuel to maneuver units and helicopters ashore in an amphibious operation, it is not designed to provide fuel for tactical jets, nor does it have the capability to do so in any significant manner. It has developed into a system whose primary use is the refueling of other helicopters.[159] The estimates for the internal fuel capacity for the JSF is approximately 16,000 pounds. A single CH-53E using TBFDS can provide fuel for only JSF with each full system at a forward base. Tying up CH-53Es to install TBFDS and fly fuel to forward bases has serious implications for a MEU composite squadron with only four CH-53Es. "No other aircraft in the inventory can duplicate the range, speed, and capacity of the Super Stallion, so one must think long and hard before committing an asset to do only one thing."[160]

One suggestion Colonel Skipper makes to support OMFTS and alleviate some of the pressures on the CH-53E is to develop LCAC-transported fuel bladders as a means of

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157 Michael J. Williams, Major General, USMC, statements made in lecture to Command and Staff College, Quantico, Va., 19 December 1997, statements are the personal opinion of MajGen Williams and not official view of the Marine Corps.

158 Skipper, 49.

159 David J. Dowling, Capt, USMC, "Tactical Bulk Fuel Delivery System: Experience From the Field," *Gazette,* January 1997, 50.

ship-to-shore bulk fuel transfer. The problem would still remain as to how to then get the fuel from the shore to dispersed forward sites. Moving fuel from ship-to-shore, and then from the shore to a maneuver element or forward site, is not a seamless transition as envisioned in OMFTS.

As aircraft dispersal becomes increasingly important, technology can help a great deal in reducing footprint. The high reliability of aircraft systems such as the JSF will reduce manpower and spare parts needs and the ability to disperse aircraft and operate out of austere sites in small numbers will be enhanced.[161] JSF technologies, with improved reliability and maintainability, must provide a significant reduction in logistics footprint while attaining the required sortie generation rates to support OMFTS. The reliability and maintainability of existing aircraft result in excessive manpower requirements which are key contributors to logistics footprint. The real challenge will not be the development of this technology but the co-ordination of technology, doctrine and tactics that need to be accomplished prior to the operational deployment of these new systems.

With the logistical shortcomings of the Marine Corps, it is apparent that although the most effective means of employing the JSF would be to base it ashore as soon as possible, it should or will need to remain sea based for as long as possible, if not entirely, where it can be more easily provided with fuel, ordnance, and maintenance. The ACE should remain entirely seabased with only minimal exceptions such as temporary FARPS, Air Control, or Air Defense elements. The rule of thumb should be: if it is not

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160 Dowling, 51.

161 Perry Smith, MajGen, USAF (ret), "The Conventional Air Battle in the Year 2000", in *The Future of UK Air Power*, (London: Brassey's Defence Publishers, 1988), 90-91.

mobile, not able to defend itself, and not needed immediately, it should remain afloat.[162] Seabasing does not require the seizure or security of airfields, ports, or beaches.

The Marine Corps should base aircraft on board amphibious shipping as much as possible. "This would solve much of the Marine Corps's problem while complicating that of any attacker."[163] Sustainability should not be a problem with aviation remaining seabased. USMC Brigadier General R.R. Blackman, former commander of the 15th Marine Expeditionary Unit (MEU) in 1994 stated that he could have supported a Harrier Forward Operating Base for very short periods of time, "but I would have spent all day using everything I had moving fuel and ordnance to support it. You want to operate off the ship, it is much easier to support."[164] Blackman would rather forward base and operate helos vice Harriers ashore due to the greatly reduced fuel and ordnance requirements.[165] Colonel Conry also believes that a MEU can logistically support Harriers ashore to an "acceptable degree, but we must recognize the limitations going into it."[166] Seabased aviation does face potential delays in surging due to turnaround time for refueling, rearming, and respotting prior to launch. If the decision is made to forward base at least some of the MAGTF's aviation, the extent and type of forward base must be supportable with organic MAGTF assets without depriving ground maneuver elements of vital support. Phasing as many helicopters ashore, especially attack helicopters, will free up precious deck space for STOVL jets and transport helicopters. In addition, helicopter

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162 *Outline Seabasing Concept,* a partial document given to the author by Major Mark E. Jaffry, USMC, Aviation Concepts Division, MCCDC, original author or source is unknown, J-B-2 to J-B-3.

163 Schneider, 97.

164 R.R. Blackman, BGen, USMC, President of Marine Corps University, interview by author, 18 December 1996.

165 Blackman interview.

166 Kevin A. Conry, Col, USMC, Director, USMC Command and Staff College, interview by author, 20 December 1996.

FARPS are much easier to support than fixed-wing sites due to the reduced weight and bulk of required supplies. While there might be situations where fixed-wing aviation will need to be established ashore, especially in MEF-sized operations, maximizing seabasing may remain the best means of enhancing sustainability and reducing vulnerability.

STOVL Jet Value. With the acknowledged limitations and historical employment of the Harrier in mind, we will now examine the value of STOVL jets to the Marine Corps. The Harrier, and the JSF that will replace it, is the only jet that deploys with USMC MEU's as dedicated fixed-wing aircraft that are "owned" by the MEU commander. According to Brigadier General Blackman the Harrier makes the MAGTF complete. "Harriers are another tool for the MEU Commander, they don't provide 24 hour capability under all conditions, but they do bring additional capability and flexibility to the MEU."[167] Blackman contends that you cannot always count on the Carrier Battle Group being there with fixed-wing support when you need them and it may be overkill (may be perceived as too threatening or offensive in delicate political situations) for some scenarios. Colonel Richard F. Natonski, USMC, a recent commander of the 24th MEU commented on the availability of the CVBG in support of the MEU:

> We didn't see the Enterprise CVBG for the entire deployment. We didn't have any integration of the CVBG and the ARG/MEU. The CVBG spent 90 days in the Persian Gulf and during that time the only fixed-wing air we had were our AV-8Bs and the aircraft landbased in Aviano, Italy.[168]

General Blackman supports the STOVL JSF, but only if it brings F/A-18 type performance and capability. "I think that if you had the same survivability, reliability,

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167 Blackman interview.

168 Richard F. Natonski, Colonel, USMC, lecture at Marine Corps Command and Staff College, Quantico, Va., 26 February 1997.

and maintainability as the F-18 with all the same or better capabilities, and the jet was STOVL, then you have the best of both worlds."

Colonel Conry also supports the all-STOVL aviation concept. He believes that it is part of our MAGTF ethos and that we should stay committed to it.[169] Colonel Conry is a big supporter of STOVL jets and says that "the real strengths of Harriers are the flexibility that they bring and that they have USMC painted on them. You don't have to worry about overfly rights or basing rights. We need to be able to rely on ourselves and the Harrier is a complimentary asset to the MAGTF."[170]

VI. Conclusion

The potential basing flexibility and firepower that the STOVL Joint Strike Fighter offers the Marine Corps in support of OMFTS will not be realized with the current doctrine and equipment that determines how we operate and support STOVL jets on amphibious ships and ashore in an expeditionary environment. Although the JSF will to be able to perform all of the missions currently flown by both the AV-8B and F/A-18 and do them better, the Marine Corps cannot just buy the aircraft without also having the ability to support it properly or to maximize its potential.

It is clear that many of the current problems faced by STOVL aviation are external to the aircraft. The Navy-Marine Corps team must develop and refine STOVL employment concepts that will optimize the basing flexibility of the JSF. Marginally supported aboard amphibious ships and difficult to support ashore in a true forward based scenario, some of the AV-8B's problems will be inherited by the JSF unless the Navy and Marine Corps provides the necessary doctrine, equipment and commitment to eliminate

169 Conry interview.

or reduce these problems. The Marine Corps believes in STOVL fixed-wing tactical aircraft, we now need a STOVL aircraft that performs as well as the F/A-18 or better. If the engineers, designers and the Marine Corps are right, the STOVL Joint Strike Fighter will be that aircraft.

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[170] Conry interview.

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